Research on the Interactive Relationship Between Regional Logistics Industry and Regional Economic Development——Take Anhui Province as An Example Based on A Comprehensive Evaluation Index System

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Abstract: This article focuses on the study of the interactive and internal relations between the regional logistics industry and regional economic development. Use the entropy method to construct a comprehensive evaluation index system for the interactive system. On this basis, the causal relationship between the regional logistics industry and the regional economy is analyzed through Granger causality test. Based on the analysis of actual data in Anhui Province, it is found that there is a one-way causal relationship between regional logistics development and regional economic development. Secondly, the grey correlation analysis method is used to calculate the correlation difference of the regional economic indicators for the development of the regional logistics industry. Finally, according to the theoretical analysis results, relevant suggestions to promote the coordinated development of regional logistics industry and regional economy are put forward.

Key words: regional logistics industry; regional economy; granger causality test; grey correlation analysis; interactive relationship

1 Introduction

Modern logistics industry is the product of economic development to a certain stage, and its development level is an important symbol of evaluating the comprehensive strength and modernization process of a city or region [1]. Regional economy is the prerequisite and foundation for the existence and development of regional logistics, and its development level affects the form and structure of regional logistics development. With the promulgation of favorable policies such as "National Logistics Hub Layout and Construction Plan" and "Three-year Action Plan for Promoting Transport Structure Adjustment (2018-2020)", the logistics industry has ushered in major development opportunities. The logistics industry is a basic, strategic and leading industry for the development of the national economy, and its importance to the development of the regional economy is self-evident. However, if the relationship between the regional logistics industry and the regional economic development is not clear, it will inevitably bring confusion to the policy-making of macro-managers and the operation and decision-making of industry managers.

The relationship between regional logistics industry and regional economic development has attracted the attention of many scholars. Munim and Schramm [2] studied the contribution of

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maritime logistics to economic development. Their research results show that improving the quality of port infrastructure in developing countries can improve logistics performance and promote rapid economic growth. Carlucci [3] studied the factors of logistics and economic performance in economic zones near European ports, and the results showed that organized and sustainable urban logistics can reduce logistics costs and increase the economic vitality of cities, thereby contributing to the economy, environment and the harmonious development of society. Yang Haoxiong, Duan Weiyu, etc. [4] constructed a system dynamics model and conducted an empirical study on the relationship between the logistics industry and economic development in the three cities of Beijing, Guangzhou, and Wuhan, and the results showed that the two are positively correlated. Song Aihua [5] constructed an evaluation model of coordination degree between China's regional logistics industry and economic development based on entropy method and composite system model, and found that regional logistics and regional economic development showed a low level of development and a high degree of coordination. Yang Huizhen [6] used the data of 11 provinces and cities in the Yangtze River Economic Belt from 2010 to 2018 and used the super-efficiency DEA model to empirically analyze the quality and efficiency of the logistics industry in various regions. Through analysis, it is found that there are regional differences in the role of logistics industry quality and efficiency in promoting economic development. Zhang Bing [7] found with the help of entropy method and gravity model that although the logistics industry integration development level among core cities in the Yangtze River Delta is relatively high, the radiation scope is relatively small, and there is no linkage effect between cities. At the same time, the results also show that the integrated development of regional logistics industry is conducive to promoting the joint development of regional economy and industry. Xu Rongrong [8] used the data of 30 provinces for 12 years as the basis to conduct regression analysis on the interaction between regional logistics and regional economy. The results show that while the development of regional logistics promotes regional economic development, there is also a spatial spillover effect.

In the research on the selection of indicators to evaluate the relationship between the two, Xu Qian and Huang Zuqing [9] used regression analysis methods to select freight turnover, passenger turnover and GDP to measure regional logistics capabilities and regional economic development levels. Relevant statistical data establishes a correlation model, and draws the conclusion that the regional logistics of Zhejiang Province is significantly related to the regional economy. Zhang Junjun [10] selected relevant statistical indicators such as freight volume, turnover volume, throughput, and total fixed asset investment to measure the level of regional internal logistics development, and used GDP to measure the level of regional economic development. Based on the actual data in Guangxi, the regression analysis method is used to conduct research, and it is found that regional logistics has a significant role in promoting economic development. Gu Shuhong and Zhou Yanrong [11] take the freight volume over the years as the regional logistics development indicator, and take the regional GDP, per capita regional product, total social fixed asset investment, total foreign trade import and export as economic development evaluation indicators, based on Guangxi Province data passed The grey relational comprehensive evaluation method analyzes the relevance of regional logistics and regional economy, and found that agriculture is an important factor affecting Guangxi's economic development. It is necessary to vigorously develop agricultural product logistics to promote Guangxi's economic development. Li Baoku and Li Pin [12] constructed a logistics industry indicator system from the two dimensions of logistics industry input and output, and constructed an economic development indicator system from three dimensions of economic growth level, residents' living

standards, and the level of opening to the outside world. Liu Guangdong, Yang Tianjian [13] and others studied the relationship between Anhui Province's logistics and economic development based on the data of Anhui Province's GDP, fixed asset investment, highway cargo turnover, post and telecommunications business volume, logistics employees, and highway mileage. The results show that regional logistics and regional economy have obvious agglomeration characteristics in global statistical analysis, but the local autocorrelation is not obvious.

To sum up, most of the current scholars focus on provinces and cities to study the relationship between the logistics industry and economic development, but there are still few in-depth discussions on the characteristics of the logistics industry and the influence process. Therefore, on the basis of previous studies, this article constructs a multi-dimensional evaluation index for regional logistics and regional economy, comprehensively uses entropy method, Granger causality analysis, and gray correlation analysis to analyze the two relatively objectively. The causal relationship and interaction process between.

2 Index selection and data processing

2.1 Selection of indicators

According to the above-mentioned scholars' research on the evaluation index of regional logistics and regional economic development.

The development of the regional economy must consider both quantitative changes and qualitative changes. Combining existing research, this paper selects four secondary indicators that reflect regional economic development (overall economic scale, development level, infrastructure investment, and commodity circulation) and five tertiary indicators. The development evaluation index of the regional logistics industry needs to comprehensively reflect the actual market vitality and potential development space of the logistics industry. Therefore, this article measures the development level of the regional logistics industry from three levels: logistics supply, logistics demand, and logistics development scale. The specific three-level indicators are shown in Table 1.

Table 1 Evaluation indicators of regional logistics industry and regional economic development

First level indicator	Secondary indicators	Three-level indicators
Regional logistics	Logistics supply	Logistics fixed asset investment X_1 (100 million yuan)
		Number of logistics employees X_2 (10 thousand people)
	Logistics demand	Highway mileage X_3 (kilometer)
		Freight volume X_4 (Billion tons)
	Logistics development scale	Total post and telecommunications business X_5 (100 million yuan)
Regional economy	Overall economic scale	GDPX_6 (100 million yuan)
	The level of development	Revenue X_7 (100 million yuan)

	Infrastructure investment	Investment in fixed assets X_8 (100 million yuan)
	Commodity circulation	Total foreign trade import and export X_9 (100 million U.S. dollars)
		The total retail sales of social consumer goods X_{10} (100 million yuan)

2.2 Data processing

The deviation standardization method is used to standardize the original data, which eliminates the influence of the dimension and order of magnitude of each variable in the original data. Let x_{ij} be the data of the j index in the i year, the specific formula is as follows:

Benefit index:

$$x_{ij}^{*} = \frac{x_{ij} - x_{\min j}}{x_{\max j} - x_{\min j}} \tag{1}$$

Cost index:

$$x_{ij}^{*} = \frac{x_{\max j} - x_{ij}}{x_{\max j} - x_{\min j}} \tag{2}$$

x_{ij}^{*} is the standardized evaluation value. Considering the effectiveness of subsequent calculations to avoid the occurrence of 0 and 1 in the result, x_{maxj} and x_{minj} adopt the values of the maximum value of the j index multiplied by 1.0001 and the minimum value by 0.9999 respectively.

The entropy method is used to determine the weight of each indicator, because the entropy method is an objective weighting method, which can calibrate the indicator data that best reflects the actual development status from many indicator data, based on the information provided by the observed value of each indicator Size to determine the index weight. The smaller the information entropy of the indicator, the higher the variation level of the indicator, indicating that the greater the amount of information provided by the indicator, the greater the impact on the evaluation result, and the greater its weight; on the contrary, the greater the information entropy of the indicator, the greater the impact of the indicator on the evaluation results. The smaller the impact of the evaluation result, the smaller the index weight. The specific formula is as follows:

Select m evaluation indicators of n annual samples to construct a judgment matrix:

$$X = (x_{ij}^{*})_{(n*m)} \tag{3}$$

Where x_{ij}^{*} is the evaluation after standardization of the data of the j index in the i year, $i = 1, 2, ..., n$, $j = 1, 2, ..., m$.

Calculate the proportion of x_{ij}^{*} in all samples:

$$p_{ij} = x_{ij}^{*} / \sum_{i=1}^{n} x_{ij}^{*} \tag{4}$$

Calculate the weight of the j index, where $k > 0, e_j \geq 0, k = 1/\ln n$:

$$e_j = -k \sum_{i=1}^{n} p_{ij} \ln p_{ij} \tag{5}$$

Calculate the difference coefficient of the j index:

$$g_j = 1 - e_j \tag{6}$$

Calculate the weight of the j index:

$$a_j = g_j / \sum_{j=1}^{m} g_j \tag{7}$$

In order to better illustrate the calculation process of regional logistics and regional economic development indicators and weights, the actual calculation is carried out in Anhui Province as an example. In addition, Anhui Province is located in the logistics hub area at the intersection of the "T"-shaped axis of my country's economic development. It is also one of the important cities in the Yangtze River Delta Economic Belt. Therefore, taking Anhui Province as an example to study the relationship between regional logistics industry and regional economy can not only promote the development of regional logistics industry and regional economy in Anhui Province, but also serve as a reference for the development of the same type of regional logistics industry and regional economy.

Combining the weight value of each indicator and the standardized data, the linear weighting method is used to construct a comprehensive evaluation index function:

$$W_i(X) = \sum_{j=1}^{m} a_j x_{ij}^{*}, i = 1, 2, ..., \mathrm{n} \tag{8}$$

Construct the comprehensive development index of regional logistics industry and regional economic system, denoted as W and J respectively, as shown in Table 2:

Table2 Regional Logistics Industry and Regional Economic Comprehensive Development Index

Years	Regional Economic Index (J)	Regional Logistics Industry Index (W)	Years	Regional Economic Index (J)	Regional Logistics Industry Index (W)
2003	0.0001	0.0272	2011	0.1788	0.1565
2004	0.0106	0.0344	2012	0.2257	0.1778

2005	0.0222	0.0303	2013	0.2732	0.2809
2006	0.0385	0.0583	2014	0.3093	0.2865
2007	0.0612	0.0684	2015	0.3433	0.3053
2008	0.0907	0.1087	2016	0.3703	0.3665
2009	0.0997	0.1260	2017	0.4236	0.3922
2010	0.1408	0.1282	2018	0.4830	0.4970

3 Granger causality test

In order to study the specific causal relationship between regional logistics industry and regional economic development, Granger causality test is used to further test. In order to eliminate the possible heteroscedasticity phenomenon in the time series, and to avoid drastic fluctuations in the series, the data is now processed by natural logarithm, that is, $\ln W$ and $\ln J$ are used for testing.

3.1 Stationarity test of time series

Use Eviews10 measurement software to test the unit root of the time series according to the ADF test model to determine whether the two sets of data have a random trend or determine the trend to prevent false regression. The results are shown in Table 3:

Table 3 Test results of variable unit roots

Variable	ADF	1% threshold	5% threshold	10% threshold	Prob.	Test result
$\ln J$	-11.4930	-3.9591	-3.0810	-2.6813	0.0000	smooth
$D\ln J$	-2.5913	-4.0579	-3.1199	-2.7011	0.1192	unstable
$D^2\ln J$	-4.5617	-4.2971	-3.2127	-2.7477	0.0069	smooth
$\ln W$	-1.2209	-4.0044	-3.0989	-2.6904	0.6336	unstable
$D\ln W$	-5.4033	-4.0044	-3.0988	-2.6904	0.0009	smooth
$D^2\ln W$	-5.5372	-4.2971	-3.2127	-2.7477	0.0019	smooth

The ADF test of the initial series shows that the ADF values of the two variables are greater than the critical value at the 5% significance level. The null hypothesis (the original data has a unit root) cannot be rejected, so the time series of the initial variables is a non-stationary series. Then, after the first-order difference and second-order difference of the variables, the ADF test was performed again. The results showed that the ADF values of the two variables after the second-order difference were less than their critical values at the 5% significance level. Based on the above test results, although the original sequence is non-stationary, after the second-order difference, the sequence can reach a plateau at a significance level of 5%. Therefore, they are second-order single integer sequences, and on this basis, the cointegration test can be performed.

3.2 Cointegration test for time series

After passing the stationarity test, it can be seen that both $\ln W$ and $\ln J$ satisfy the premise of the cointegration test, and then the Engel-Granger two-step test is used for the cointegration test. Then, perform least squares regression on $\ln W$ and $\ln J$ to obtain the regression model estimation results, and perform ADF unit root test on the residual sequence obtained. The results are shown in Table 4:

Table 4 Test results of Engel-Granger two-step test

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-5.7106	0.0011
Test critical values:	-4.2000	-4.2000	
	-3.1754	-3.1754	
	-2.7290	-2.7290	

According to Table4, the P value is less than 0.05, and the null hypothesis is rejected, indicating that the data has a co-integration relationship at the 5% significance level. The results of the co-integration test show that there is a long-term equilibrium relationship between the regional economy and the regional logistics industry. In order to analyze the specific causality and interaction, it is necessary to make further judgments through the Granger causality test.

3.3 Granger causality test

Knowing that $\ln W$ and $\ln J$ meet the conditions of time series stability, the following uses Eviews10.0 software to perform Granger causality test on the data, and the results are shown in Table 5.

Table 5 Granger causality test results

H_0 hypothesis	Degree of freedom	F value	Prob.*	Conclusion
$\ln W$ is not a Granger reason for $\ln J$	14	0.76299	0.4942	Accept
$\ln J$ is not a Granger reason for nW	14	7.45952	0.0123	Refuse

It can be seen from the test results in Table 5 that at the 5% significance level, the regional economy is the Granger cause of regional logistics. The reason for this one-way causality is that the further development of the regional economy will release more logistics demand, so the development of the regional economy can directly drive the development of the regional logistics industry. However, the basic and leading characteristics of the logistics industry make it impossible to form direct economic benefits in the short term. Moreover, the strategic characteristics of the development of the logistics industry will also make the spillover effect of

the development of the regional logistics industry more obvious, and its influence will extend to a wider surrounding area, and it may even benefit the outer area rather than the local area first. The test results show that the interaction between the development of the logistics industry and the economic development is unbalanced. In order to form a benign interactive relationship between the two, the top priority should be to make up for the shortcomings of the logistics and supply chain ecosystem construction, further consolidate the construction of logistics infrastructure, information infrastructure and other hardware environments, and increase capital, taxation and land use. Policy support in other aspects, to create a good business environment for the development of the logistics industry, and to promote the high-quality development of the national economy through the high-quality development of the logistics industry.

4 Grey relational analysis

Granger causality test shows that regional economic development is the Granger reason for the development of regional logistics industry. However, how to accelerate the development of regional logistics industry and improve the quality of logistics development? In order to refine the impact of the regional economy on the development of the logistics industry, it is necessary to study the different impacts of various indicators of regional economic development on the regional logistics industry, so as to formulate targeted support policies to effectively improve the development level of the regional logistics industry.

In order to accurately reflect the gray correlation degree between the various indicators of the regional economy and the comprehensive development index of the regional logistics industry, taking the comprehensive development index of the regional logistics industry in Anhui Province as the parent sequence, the process of calculating the gray correlation degree is given.

Table 6 Grey correlation degree between regional economic indicators and the development of regional logistics industry

Index	GDP	Revenue	Investment in fixed assets	Total foreign trade import and export	The total retail sales of social consumer goods
Yangtze River Delta Relevance	0.8336	0.8137	0.8172	0.6488	0.7989
Relevance of Anhui Province	0.7493	0.7399	0.7376	0.6665	0.7256

The data is processed according to the data and the above formula, and the minimum value is 0.0195, the maximum value is 0.4313, and the resolution coefficient is 0.5. The gray correlation degree between regional economic development and regional logistics development can be obtained. In addition, the development of regional logistics industry will radiate a wider range of economic regions, so when studying the development of regional logistics industry and regional economy, only confining the research perspective to a fixed area may bring deviations. Therefore, this article compares the correlation between the development of the regional logistics industry and the same regional economic development, and the correlation between the

development of the regional logistics industry and the economic development of all radiating regions. Take Anhui Province as an example. With the further implementation of the national integrated development strategy of the Yangtze River Delta, Anhui Province, a logistics hub area located at the intersection of the "T"-shaped axis of my country's economic development, will gain a greater share in the overall development of the Yangtze River Delta economic sector. Space for development. Table 6 shows the gray correlation between the regional economic indicators of Anhui Province and the Yangtze River Delta (Jiangsu, Zhejiang, Shanghai and Anhui) and the comprehensive development index of logistics industry in Anhui Province.

Regardless of the indicators of the Yangtze River Delta regional economy or the economic indicators of the regional economy of Anhui Province, the order of relevance to the development of the regional logistics industry in Anhui Province is generally the same, but the regional economic indicators of the Yangtze River Delta urban agglomerations The development of the logistics industry has a greater degree of influence. This shows that the development of regional logistics industry is affected by the economic development of different regions, and there are certain differences in the effect of its impact. The strategic and basic characteristics of the regional logistics industry will make it more closely related to the economic development of the larger region than in this region. Therefore, for regional economies with good synergy, promoting the development of regional logistics industry will not only focus on the factors of economic development in the region.

A summary of Table 6 finds that the economic factors affecting the development of the regional logistics industry are ranked as follows:

Gross Regional Product> Investment in Fixed Assets (Financial Revenue)> Total Retail Sales of Consumer Goods> Total Foreign Trade Imports and Exports

From the above analysis, the total amount of foreign trade import and export has the least impact on the regional logistics industry, and the other factors are closely related to the development of the regional logistics industry, and the regional GDP is the most closely related.

The correlation of regional GDP is higher than other indicators, indicating that the high-level and high-quality development of the economy is the prerequisite and foundation for the development of the regional logistics industry. Economic growth is closely related to the characteristics of economic structure. According to the data released by the China Statistical Yearbook, my country's secondary and tertiary industries will contribute 43.3% and 47.3% to GDP in 2020, indicating that the secondary and tertiary industries are the main drivers of my country's economic growth. power. The linkage between the regional logistics industry and the manufacturing industry and other secondary industries is the foothold for realizing the positive interaction between regional economic development and the development of regional logistics industry.

The impact of the total investment in fixed assets is second only to the regional GDP, and logistics infrastructure is the cornerstone of the development of a regional logistics industry. In recent years, governments at all levels have paid more and more attention to the construction of fixed assets investment, focusing on infrastructure such as railways, highways, water conservancy, energy, etc., and have made key investments in the construction of logistics infrastructure and the planning and construction of logistics parks. Compared with other factors, the high degree of relevance of total fixed asset investment means that the direct investment of

management departments in the logistics industry will be the most effective management method, and it is also the most powerful tool for policy makers.

Fiscal revenue and total retail sales of consumer goods are closely related to the logistics industry, indicating that the increase in government fiscal revenue and urban residents' consumption levels can expand the demand for the logistics industry and enable the logistics industry to develop and grow rapidly. The increase in the consumption level of residents shows that people are willing to spend money on shopping and stimulate the development of logistics-related industries such as e-commerce and express delivery. In turn, the development of logistics and related industries can promote rapid, stable and reasonable economic growth. The two complement each other and promote each other.

5 Conclusion and suggestion

The development of the regional economy has spawned a huge demand for logistics, thereby prompting the rapid development of the regional logistics industry. Regional logistics acts as the forerunner of regional economic development, providing services and support for regional economic development. In-depth analysis of the internal relationship between the regional logistics industry and the regional economy can point out the direction for the development of regional logistics. This paper constructs a comprehensive data index system through the entropy method, and uses Granger causality test and grey correlation analysis to analyze the interactive relationship between regional logistics and regional economy, and draws the following conclusions: (1) Regional logistics industry development It is not the direct cause of regional economic growth, but the co-integration test shows that there is a long-term equilibrium relationship between the two. (2) The gray correlation analysis shows that the average correlation degree of the influence of regional economic factors on the development of regional logistics is generally higher (greater than 0.6), and the linkage is better, for Anhui Province. From the results of the example analysis, the regional GDP factor has the greatest correlation influence on the development of regional logistics industry, and the correlation influence of foreign trade import and export factors is the smallest. On the contrary, the promotion effect of my country's regional logistics industry development on regional economic development is still relatively weak. As General Secretary Xi Jinping emphasized at the eighth meeting of the Central Committee of Finance and Economics: my country's circulation system is still not modernized, and there are still some blocking points that need to be solved urgently. Based on the above conclusions, the following three suggestions are put forward for the development status of regional logistics industry and regional economy:(1) Develop modern logistics industry clusters and build logistics hubs. (2) Integrated development of logistics industry and secondary industry, integration and innovation. (3) Strengthen the construction of logistics infrastructure and increase the utilization rate of facilities

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